Fleeting Orders and Dynamic Trading Strategies: Evidence from the Australian Security Stock Exchange (ASX)

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This study examines the behaviour of fleeting orders before and after two structural changes at the Australian Securities Exchange (ASX); the removal of broker IDs from the public limit order book and a change in the price structure of exchange fees. Following Hasbrouck and Saar (2009), fleeting orders are defined as orders that are revised or cancelled within two seconds. Firstly, this study confirms that fleeting limit order revisions exhibit similar properties to liquidity-demanding orders. Secondly, after the removal of broker IDs on the market, traders start to aggressively chase the market price. Thirdly, after the price structure changes, traders start to use fleeting orders to search for latent liquidity and more often switch from limit orders to market orders when the cost of immediate execution in the market decreases. This study is important to understand order dynamics in the current high frequency trading environment.

INTRODUCTION

Hasbrouck and Saar (2009, p.146) highlight the importance to recognise "new ways in which trading and order choices have changed as a results of improved technology, active trading culture, market fragmentation, and an increasing utilization of latent liquidity". The authors suggest two models. The first are dealer models, which are often modelled as risk-neutral liquidity suppliers, who are indifferent as to whether their bids and offers are executed, and who let their bids and offers remain in the limit order book until there is a trade. The second are strategic models whereby traders decide whether to supply or demand liquidity. For example, in the presence of a wide spread, traders with a strong desire to trade might rather choose to submit a limit order.

The authors investigate limit order activity in strategic models and question the traditional view of limit orders as patient suppliers of liquidity. In particular, they show that 37% of limit orders traded on

NASDAQ through electronic communication network (ECN) are cancelled within two seconds of submission. They explain that this is a recent phenomenon, which they refer to as fleeting orders and investigate their role in dynamic trading strategies. Similar to Hasbrouck and Saar (2009), this study examines the trading behaviour of fleeting orders around unique market structure changes at the Australian Securities Exchange (ASX).

The market structure changes are as follows; a) the removal of broker IDs from the public limit order book, and b) a series of changes in the price structure for exchange fees. The removal of broker IDs was implemented on 28 November 2005. The impact of broker anonymity is extensively documented in the literature. For example, Foucault, Moinas and Thiessen (2007) examined the effect of broker anonymity on Paris Euronext and found that quoted bid-ask spreads decline and quoted depth decreases when broker IDs are withheld. Comerton-Forde and Tang (2009) examined market quality when the ASX moved to an anonymous regime and found three major improvements in market quality; a) reduction in quoted spreads, b) increase in quoted depth and c) greater order flow.

Broker identifiers provide valuable information in the limit-order book; for example, they explicitly offer free information in the trading process (O'Hara 1995). Large (2004) argue that traders who arrive at the market uncertain of its state can quickly learn its true state by placing a limit order and watching the evolution of the market. If the uncertainty is quickly resolved, limit orders are quickly cancelled. Therefore, fleeting orders are used as part of an optimal strategy. The author argues that uncertainty can increase the placement of limit orders, since the option to cancel reduces downside risk, while the upside potential remains.

Foucault et al. (2007) explain, because in anonymous markets, uninformed traders cannot distinguish informative orders from non-informative orders, their bidding behaviour is driven by their belief about the identity of the traders with orders in the limit order book. The authors confirm that the removal of broker IDs affects the liquidity of a limit order market. In particular, they find a significant decrease in various measures of the quoted spread and effective spread after the switch to an anonymous limit order book. Overall the authors suggest that the switch to anonymity has improved market liquidity and agree that the limit order book contains information on the magnitude of future price changes. However, a switch to anonymity reduces the informativeness of the bid-ask spread when it improves market liquidity.

The removal of broker IDs is an excellent opportunity to examine fleeting orders. Especially because uninformed traders are not able to identify informed traders in anonymous markets, and as a results fleeting orders may be used as a vehicle for uninformed traders to learn about expected future price movement.

The ASX announced a range of enhancements to the trade execution service that was implemented on 28 June 2010.[1] In particular, headline trade execution fee is reduce from 0.28 basis points to 0.15 bps, on-market crossing and off-market crossing execution fees are reduce from 0.15 bps to 0.10 bps, and from 0.075 bps to 0.05 bps respectively. In addition, new order types are introduced. These are undisclosed orders and CentrePoint crossing orders.[2] Undisclosed orders are undisclosed to the general market as to volume, but disclosed as to price - provided the order size is above a specified threshold of AU$500,000. CentrePoint Orders are anonymous orders that enable execution at the prevailing midpoint of the best bid and offer of the Central Limit Order Book (CLOB).[3] This reduction in ASX fees lowered the direct costs of trading for ASX participants, while the new systems and order type functionality were introduced with the intention to lower market impact costs such as price slippage. These are all initiatives taken by ASX to attract and retain algorithmic trading business by creating a favourable environment for it.

These enhancements to trade execution service are another opportunity to examine the role of fleeting orders. Firstly because the reduction in exchange fees make it more affordable to frequently submit, revise and cancel orders. Secondly the introduction of new order types such as undisclosed orders can increase the use of fleeting orders in dynamic trading strategies. For example, traders place a limit order within the spread with the intention of immediate execution against an undisclosed order. If immediate execution does not occur, the limit order is quickly revised at a more aggressive price to ensure execution against a hidden order.

This study examines; a) the characteristics of limit order book, b) what happen to limit orders after submission, c) the market conditions that influence the probability of fleeting and non-fleeting orders and d) the role of fleeting orders in dynamic trading strategies.

Similar to Hasbrouck and Saar (2009) this study proposes three hypotheses to explain the use of fleeting orders in dynamic trading strategies. These are as follows; a) Chase hypothesis - this hypothesis states that fleeting orders arise as traders chase prices that are moving away by cancelling the existing orders and repricing their orders; b) Search hypothesis - this hypothesis states that fleeting orders are used to search for hidden liquidity in the book; and c) Cost-of-immediacy hypothesis - this hypothesis states that fleeting orders arise when existing limit orders are cancelled to be resubmitted as marketable orders.

The results reveal several interesting results. These are as follows; a) The percentage of limit orders that are fully executed decreases after both market structure changes. This is consistent with Hasbrouck and Saar (2009) who find a low fill rate for INET. They explain that this indicates the importance to recognise new ways in which trading and order choices have changed due to technology, active trading, fragmentation, and latent liquidity. b) Large market capitalisation stocks, in both market structure changes show that the most probable event 2 seconds after a limit order is submitted or revised is a subsequent revision. This confirms that traders who arrive at the market uncertain of its state quickly learn its true state by placing a limit order and watching the evolution of the market. If the uncertainty is quickly resolved, limit orders are quickly cancelled or revised. c) Large market capitalisation stocks, after both market structure changes show that fleeting cancellations are mostly placed at-the-market. Before and after the removal of broker IDs, fleeting revisions are mostly placed behind-the-market. However, before the price structure change, fleeting revisions are mostly placed behind-the-market and after the price structure change, fleeting revisions are mostly placed ahead-of-the-market. d) The behaviour of limit order revisions that are subsequently revised (within 2 seconds) behaves more like market orders that demands liquidity. e) After the removal of broker IDs, traders pursue a dynamic strategy in which they revise limit orders as the market moves away from the original limit order. After the price structure change, fleeting orders are used to search for latent liquidity within the spread and traders more often switch from a limit order to a market order as it becomes cheaper to demand than to supply liquidity.

LITERATURE REVIEW

The study of limit order revisions in the ASX has recently witnessed growing interest. Liu (2009), and Fong and Liu (2010) offers valuable characterizations of order revisions. Liu (2009) proposes that the decision to cancel a limit order is a function of; a) the risk of a being picked off by traders that are more informed and b) the risk of a non-execution because the price moves away from the trader. The use of computers in the trading process has enabled limit order traders to monitor their limit orders more closely. Thereby, making more strategic decisions to place, cancel or revise orders to reduce pick off risk or non-execution risk. Fong and Liu (2010) empirically test the relation between limit order revisions, the management of free trading options, non-execution risks and monitoring costs. They suggest, alleviating the risk of being picked-off or the risk of non-execution, traders can monitor the market and cancel or revise orders accordingly. They find that order revision activity is higher when order submission risks are higher, when spreads are narrower, and when the concerned firm is larger.

Yeo (2005) investigates the motivation behind cancellations and test two trading strategies that accordingly to them, accounts for up to 85% of all cancellations on NYSE. The first strategy is an order splitting strategy, were a limit order trader wishes to hide large buying or selling orders by breaking it into smaller ones. The second strategy is when more than one trader submits limit orders to gain price priority over one another within a short time interval. This is referred to as the “undercutting strategy” Yeo (2005, p.11). Unsuccessful traders are faced with the following options; a) cancel their orders and resubmit with the intention of further undercutting or b) exit the market altogether. Yeo (2005) finds that; a) most traders withdraw from trading in the stock subsequent to cancellation, b) if they choose to continue to trade, they are much more likely to resubmit their orders with more aggressively priced limit orders rather than market orders.

Cao et al. (2008) examine whether and to what extent the state of order book affects investors' order placement strategies. The state of the book includes its depth (i.e. quantity) and its height (i.e. price dimension along the book). In addition to the choice of using market or limit orders, they differentiate among limit orders according to their position in the book. They find that the top of the book always affects order submissions, cancellations, and revisions, and the rest of the book predominantly affects order cancellations and revisions. Further evidence linking order cancellations and monitoring costs is found in Boehmer, Saar and Yu (2005). They document an increase in the intensity of limit order cancellations and a decrease in time-to-cancellations after the introduction of NYSE's OpenBook. The relation between order revisions and free-option risk is also documented by Biais et al. (1995). They find that after large sales (buys), which convey negative (positive) information, the rate of cancellations increases on the buy (sell) side of the book.

Closely related to this study, Hasbrouck and Saar (2009) examine the behaviour of fleeting orders in dynamic trading strategies. They argue that fleeting orders exhibits different characteristics than limit orders that remain in the limit order book for more than two seconds. They emphasise the complex nature of liquidity provision and how it has changed from the previous decade. Several interesting questions that arise from Hasbrouck and Saar (2009) are for example: Has the cancellation rate increased or decreased over time? How does different market structure and markets, affect the cancellation rate?

The remainder of this study is organised as follows. The next section provides institutional background and data, Section 4 outlines the hypotheses that are tested, Section 6 discusses the research design, Section 7 presents the empirical analysis and Section 8 concludes.

INSTITUTIONAL BACKGROUND AND DATA

The ASX is a centralised electronic limit order book market that takes place on an Integrated Trading System (ITS). Traders may enter, revise or cancel orders in the trading system from the pre-open phase commencing at 7:00; however, the trading system does not match orders until the market opens. The opening call auction algorithm starts at 10:00 and completes the opening procedure of all stocks by 10:10. Normal continuous trading follows the opening call auction and ends at 16:00. The closing call auction algorithm operates at 16:10 to establish the closing price of the day.

The market structure changes that are examined are as follows; a) the removal of broker IDs from the public limit order book, and b) a series of changes in the price structure for exchange fees.

Since the beginning of the electronic screen trading via SEATS, brokers have been able to identify in real-time the broker identification number associated with the order in the central limit order book (CLOB) for each security. Since 28 November 2005, all equity trading on ASX has been anonymous, i.e., broker identifiers are not displayed.

The ASX announced a range of enhancements to the trade execution service offering. A reduction in trade execution fees and the introduction of new order types were implemented 28 June 2010.[4] In particular, trade execution fee was reduce from 0.28 basis points to 0.15 bps and on-market crossing and off-market crossing execution fees was reduced from 0.15 bps to 0.10 bps and from 0.075 bps to 0.05 bps respectively. New order types introduced, were undisclosed and CentrePoint crossing orders[5].

The dataset used in this study is limit order book data provided by the Securities Industry Research Centre of Asia Pacific (SIRCA). The limit order book data contain details on every order submitted to the ASX, including the order type (order submission, order revision, order cancellation), the date and time to the nearest hundredth of a second, stock code, order price, order volume and order direction (buy or sell order). Each new order is assigned a unique identification number (ID), which allows for the tracking of every order from its initial submission through to any revision, cancellation or execution. This dataset also contains information regarding whether the order is partially revealed. In addition, intraday bid-ask quotes are obtained from SIRCA. This dataset provide information on stock code, date, time to the nearest hundredth of a second, and the best bid and ask quotes in the limit order book.

ASX 200 companies are ranked according to their equity market capitalisation from August 2005 to September 2010. These companies are divided into quartiles, from which the first 20 companies within each quartile are selected, thereby obtaining a size-stratified subsample of 80 stocks from among 200 stocks. The period includes 3 months before and 3 months after each market design change. Therefore, the removal of broker IDs includes period between August 2005 and February 2006, and price structure change includes a period between March 2010 and September 2010.

Table 1 presents summary statistics of S&P 200 stocks that are ranked based on equity market capitalisation. These statistics are the average number of daily trades, the average daily volume, the average daily closing price, the standard deviation of the daily returns and average relative spread. Panel A presents statistics before and after the removal of broker IDs. Large market capitalisation stocks show an average of 1019 trades per day and an average volume of 2,332 (thousand) per day. Small market capitalisation stocks show an average of 61 trades per day and an average volume of 395 (thousand) per day. Panel B presents statics before and after the price

TABLE 1
DESCRIPTIVE STATISTICS

This table presents summary statistics of S&P200 stocks that are ranked based on equity market capitalisation. For each quartile the top 20 stocks are included. Q1 presents large market capitalisation stocks and Q4 presents small market capitalisation stocks. Panel A and B presents descriptive statistics 3 months before and 3 months after the removal of broker IDs and the change price structure, respectively. The removal of broker IDs is implemented on 28 November 2005 and price structure change is implemented on 28 June 2010. The following variables are calculated: market cap is the average market capitalisation, number of trades is the average number of daily trades, daily volume is the average daily volume, price is the average daily closing price, std ret is the standard deviation of the daily returns and relative spread is the daily average relative spread. This table presents cross-sectional summary statistics. Standard deviations are in parentheses.

Market Cap Groups	Market Cap ($million)	Number of Trades	Daily Volume ($thousands)	Price	Std Ret	Relative Spread
Panel A: Removal of broker IDs						
Q1	23,166	1,019	2,332	21.31	0.083	0.228
	(20,575)	(767)	(2487)	(14.76)	(0.477)	(0.320)
Q2	3,209	283	889	12.28	0.213	0.300
	(1,131)	(157)	(1031)	(15.42)	(1.363)	(0.208)
Q3	1,151	175	621	4.41	0.251	0.434
	(356)	(133)	(940)	(3.64)	(1.06)	(0.185)
Q4	249	61	395	3.06	0.970	1.391
	(159)	(63)	(966)	(3.05)	(5.74)	(1.488)
Panel B: Price structure change						
Q1	33,276	5,787	3,313	23.48	0.027	0.120
	(33,371)	(3620)	(3367)	(17.06)	(0.017)	(0.110)
Q2	3,669	2,084	2,252	11.09	0.059	0.203
	(2,065)	(1259)	(2926)	(16.39)	(0.070)	(0.546)
Q3	1,377	989	2,074	3.29	0.101	0.390
	(744)	(829)	(3874)	(4.52)	(0.065)	(0.433)
Q4	1,016	1120	1,528	5.17	0.187	0.570
	(654)	(834)	(3389)	(4.64)	(0.063)	(0.239)

structure change. Large market capitalisation stocks show an average of 5,787 trades per day with an average volume of 3,313(thousand) per day. Small market capitalisation stocks show an average of 1,120 trades per day with an average volume of 1,528 (thousand) per day.

Table 2 presents summary statistics of the average number and size of limit-, market-, cancelled - and revised orders. Panel A presents statics for the removal of broker IDs and Panel B presents statistics for price structure change. Large market capitalisation stocks, before the removal of broker IDs show an average of approximately 17,372 limit orders and 12,781 market orders per day. After the removal of broker IDs, limit orders increase to 19,078 and market orders increases to 14,095 per day. Furthermore, after the removal of broker IDs, the number of limit order revisions increased from 10,629 to 14,703 per day, while the number of market cancellation slightly increases from 5,709 to 6,735 per day.

Large market capitalisation stocks, before the price structure change show an average of approximately 213,208 limit orders per day, which increases to 225,040 after the price structure change. In addition, market orders before the price structure change show an average of 52,560 orders per day, which increases to 54,818 after the price structure change. Large market capitalisation stocks before the price structure change show an average of 218,916 revisions and 106,437 cancellations per day, which increases to 228,521 and 120,731 respectively.

TABLE 2

SUMMARY STATISTICS OF LIMIT ORDERS, MARKET ORDERS, CANCELLED ORDERS AND REVISED ORDERS

This table presents summary statistics of order submissions in the limit order book. Panel A and Panel B presents the statistics 3 months before and 3 months after the removal of broker IDs and price structure change, respectively. Results are reported in quartiles were Q1 presents large market capitalisation stocks and Q4 presents small market capitalisation stocks. The following variables are calculated: daily average number and size of limit orders, market orders, cancelled orders and revised orders. Standard deviations are in parentheses.

	Pre-Event								Post-Event							
	Limit Orders		Market Orders		Cancelled Orders		Revised Orders		Limit Orders		Market Orders		Cancelled Orders		Revised Orders	
MktCap	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size	Number	Size
Panel A: Removal of broker IDs																
Q1	17,372	5,299	12,781	4,660	5,709	4,582	10,629	3,509	19,078	4,803	14,095	4,252	6,735	4,146	14,703	5,504
	(2,052)	(636)	(2,549)	(662)	(896)	(1,008)	(1,904)	(792)	(3,552)	(588)	(4,677)	(785)	(1,384)	(950)	(4,031)	(1,371)
Q2	7,467	7,587	2,905	8,092	3,098	5,510	3,414	5,025	8,254	6,922	3,227	6,873	3,514	4,972	5,106	9,427
	(1,016)	(1,428)	(709)	(2,355)	(477)	(1,122)	(950)	(1,285)	(1,626)	(1,045)	(1,048)	(1,660)	(644)	(1,203)	(1,523)	(2,395)
Q3	4,155	7238	1783	6,773	1,844	4,297	1,605	6,644	4,737	8,370	2,152	7,060	2,078	5,324	3,283	10,618
	(673)	(1365)	(577)	(2,195)	(374)	(3,101)	(320)	(1,058)	(835)	(1,900)	(820)	(2588)	(303)	(1141)	(1136)	(2425)
Q4	1,553	12,233	592	11,205	669	6,369	574	14,053	1,704	11,618	717	9,088	716	7,700	919	10,428
	(266)	(5,218)	(182)	(5,234)	(163)	(3,654)	(1,41)	(5,481)	(415)	(5,149)	(271)	(5,610)	(188)	(9,367)	(330)	(9,578)
Panel B: Price structure change																
Q1	213,208	1,223	52,560	1,481	106,437	1,480	218,916	1,277	225,040	1,184	54,818	1,362	120,731	1,535	228,521	1,749
	(64,117)	(150)	(16,268)	(328)	(36,649)	(347)	(91,816)	(754)	(33,723)	(147)	(8,919)	(386)	(19,638)	(187)	(58,442)	(641)
Q2	87,431	2,353	21,076	3,529	48,512	2,311	77,723	2,488	93,437	2,230	25,644	3,165	55,956	2,324	79,076	2,795
	(20,783)	(459)	(4,675)	(1,103)	(12,493)	(459)	(30,862)	(1,368)	(12,036)	(355)	(5,120)	(1,170)	(7,517)	(392)	(13,670)	(1,138)
Q3	43,626	5,139	12,449	5,664	25,119	3,942	37,915	5,995	47,404	4,685	14,033	4,646	29,665	4,104	40,318	6,472
	(8723)	(1211)	(3265)	(1991)	(5006)	(702)	(13623)	(6265)	(6,257)	(1,001)	(4,282)	(1,716)	(4,675)	(1,124)	(7,028)	(5,617)
Q4	41,926	2,631	9,632	2,713	22,223	2,358	3,5791	2,342	46,928	2,510	12,826	2,367	28,104	2,227	39,607	2,056
	(9,922)	(489)	(2,368)	(758)	(6,433)	(358)	(15,658)	(2,056)	(7,038)	(501)	(3,523)	(994)	(4,943)	(320)	(7,466)	(700)

HYPOTHESIS TESTING

Following Hasbrouck and Saar (2009), the hypothesis tested are; chase –, search – and the cost of immediacy hypothesis. These hypotheses are tested pre- and post- each market structure change in ASX.

> *Hypothesis$_{1.1}$: Trader revises and re-submits limit order at a more aggressive price as the market moves away from the original limit price. Limit order revision and re-submission increases after each market structure change.*

Hasbrouck and Saar (2009) refer to this hypothesis as chase hypothesis. The proposition of this hypothesis is that the trader actively influences the likelihood of an execution by using fleeting orders in dynamic strategies in response to changing market conditions.

> *Hypothesis$_{1.2}$: Trader cancels limit order and switch to a market order, in response to a drop in the cost of immediate execution. Limit order cancellation increases after each market structure change.*

Hasbrouck and Saar (2009) refer this as the cost-of-immediacy hypothesis. This hypothesis states that fleeting orders are part of a dynamic strategy in which traders cancel a limit order and switch to a market order when the cost of immediate execution in the market decreases. Similar to previous hypothesis, this hypothesis specifically state that fleeting orders are a by-product of dynamic strategies involving order revision in response to changing market conditions.

> *Hypothesis$_{1.3}$: Trader submits limit order within the spread to achieve immediate execution against a hidden order or attracting a new marketable order. If neither occurs within a brief interval, the limit order is revised. Limit order revision increases after each market structure change.*

Hasbrouck and Saar (2009) refer to this hypothesis as search hypothesis. This hypothesis states that fleeting orders are outcomes of strategies that seek latent liquidity. Hasbrouck and Saar (2009, p.144) explain that the term "latent" comprise hidden limit orders that are available for execution but are not displayed. It also extend to counterparties who are actively monitoring the market and will immediately hit an aggressively priced limit order, but who are unwilling to pre-commit to a price of limit order that is either displayed or not.

In particular, this hypothesis states that fleeting orders are intended to demand, rather than supply, liquidity. It is less aggressive than a market order strategy, but it is not a patient limit order. The trader does not intend to keep it in the book to benefit from execution against the incoming order flow.

METHODOLOGY

Fill Rate of Limit Orders

In this section, the percentage of limit order submissions, executions, partially executions and fully executions are determined. Limit order IDs are used to track limit orders until execution. Thus, if the volume of limit order at submission equals the total volume of all trades executed (with the same order ID) then the limit order is fully executed, else partially executed.

The percentage of limit orders submitted is calculated as the number of limit orders that are submitted, divided by the sum of limit and market orders submitted. The percentage of limit orders executed is calculated as the number of limit orders that are executed, divided by the total number of limit orders submitted. Fully and partially executed orders are calculated as the proportion of limit order that are executed. Table 3 reports the cross-sectional averages for the percentage of limit orders submitted, executed, fully executed and partially executed.

Hasbrouck and Saar (2009) argue that in the presence of fleeting orders, the fill rate is a misleading and inappropriate metric of quality. They explain “a higher fill rate indicates a greater likelihood of finding counterparty and therefore a better market”. (e.g. Hasbrouck and Saar, 2009, p.146) However, they find that the fill rate for INET is low, yet it is a highly successful venue that ultimately chosen by Nasdaq as its primary platform. They emphasise that this finding indicates the importance to recognise the new ways in which trading and order choices have changed due to technology, active trading, fragmentation, and latent liquidity.

Survival Analysis

The survival analysis is used to determine what happens to limit orders after submission. More specifically, the life-table method is used to estimate the survival function, where the distribution of survival times is divided into a certain number of intervals. For each interval the number and proportion of events that entered the respective interval, the number and proportion of events that failed in the respective interval and the number of cases that were lost or censored in the respective interval are computed. In the estimation process for cancellations and revisions the censoring event is execution (and vice versa).

The time intervals are measured from the submission of limit order to the subsequent event and from the revision of limit order to the subsequent event, i.e. revision, cancellation or execution. The probabilities are computed as 1-S(t), where S(t) is the survival function. Let λ denote the time between order submission (or revision) and cancellation, revision or execution. The probability of cancellation or revision in the interval $(0,t)$ is the distribution function $P_{event}(t) = \Pr(\lambda \le t)$. The probabilities are estimated separately for each stock. Table 4 reports the cross-sectional averages for cancellation, revision and execution probability.

Placement of Fleeting Orders

In this section, the placement of limit orders are examined, to determine whether fleeting orders are placed ahead, at or behind the same-side best bid and offer prices (BBO). For example ahead of same-side BBO, for a buy means that it was submitted at a price that is higher than the best bid. If a limit order has more than two revisions and the price has change since submission, then the updated price will be use to determine whether the subsequent order (i.e. fleeting or non-fleeting revision or cancellation) is placed ahead, at or behind the market.

First, the percentage of fleeting and non-fleeting cancellations and revisions is calculated relative to each group (i.e. fleeting and non-fleeting). Second, fleeting and non-fleeting revisions and cancellation are then sub-classified by the location of the limit order price, relative to the same-side BBO at the time the order was submitted or revised. The sub-classifications are; a) ahead of BBO, b) at BBO, c) behind BBO. The percentage of each sub-classification is reported, which sum vertically to 100% within each category. Table 5 reports the cross-sectional averages.

Hasbrouck and Saar (2009) show that approximately 36% of fleeting orders are priced ahead of the same-side INET best bid or offer (BBO), while only 20.73% of non-fleeting cancelled limit orders are priced ahead of the BBO. In other words, fleeting orders are priced more aggressively. They suggests, submitting a limit order at a slightly better price may be to a) jump to the head of the queue, or b) it could indicate a search for hidden orders whereby the searcher first tries the most favourable price and then sequentially searches for hidden orders at worse prices.

Multinomial Logit Analysis

Hasbrouck and Saar (2009) explain, if fleeting orders behave different to limit orders that remains in the book for more than two seconds (i.e. regular limit orders), further examination of fleeting orders would be meaningless. Similar to Hasbrouck and Saar (2009), the multinomial logit model is adopted to confirm a meaningful partition of the limit order set. In essence, the multinomial logit, predicts the probabilities of different possible outcomes of a categorically distributed dependent variable.

The logit model is estimated twice. The first estimation examines the behaviour of fleeting revisions and cancelations directly after submission, while the second examines the behaviour of fleeting revisions and cancelations directly after revision. The events (categories) in the first estimation are as follows: a) limit orders that are cancelled within two seconds b) limit orders that are revised within two seconds, c) limit orders that are executed within two seconds, d) limit orders that persist on the book for more than two seconds ('regular limit orders'), and e) market orders. Regular limit orders are the reference event.

The events in the second estimation are as follows: a) limit orders that are cancelled within two seconds, b) limit orders that are revised within two seconds, c) limit orders that are executed within two seconds, and d) limit orders revisions that persist in the book for more than two seconds ('regular limit order revisions'). In this case, regular limit orders revisions are the reference event.

This model is estimated for large (Q1) and small (Q4) market capitalisation stocks. The period examined is a combined period of 6 months, that includes 3 months before and 3 months after the removal of broker IDs and the price structure change. The sample is comprised of stocks *i* and events for each stock marked at *t*. Within each stock, a lower value of the index *t* represents an earlier event than one with a higher value of *t*. Hasbrouck and Saar (2009, p.157) explain that these events are essentially asynchronous across stocks even though the data for all stocks is taken from the same overall time period. For example, the event marked for one stock generally does not take place at the same instant as the event for a different stock.

The explanatory variables are intended to capture dynamic variation in market conditions. These are; a) prevailing spread, which reflects the cost of obtaining immediacy in the market, b) volume and volatility (absolute value of return) over the prior five minutes, which are intended to capture the variation in momentum of market activity and c) time-of-day dummy variables, which are intended to capture deterministic intraday patterns. The spread, lagged volume and lagged absolute value of return are standardised within each firm to have zero mean and unit variance.

Hasbrouck and Saar (2009) suggests, to assist with the interpretation of this model, the base case is calculated. The base case is the implied event probability when all explanatory variables are set to their means.[6] The implied probabilities are then examined when each of the variables, taken one at a time, increases by one standard deviation. Table 4 reports a) the base case and b) the difference relative to the base case when each explanatory variable increased by one standard deviation. Standard errors are computed, using the delta method. In addition, the inclusion of the firm-dummies ensures that the average (within stock) residuals are essentially zero.

Let $\pi_{i,j,t}$ be the probability that event *t* for firm *i* has outcome j. The reference event is j = 0, that is, a regular limit order. The multinomial logit model can be written as:

$$\log(\frac{\pi_{i,j,t}}{\pi_{i,t,0}}) = a_{i,j,0}d_{i,j} + a_{j,1}\begin{pmatrix}\text{Relative}\\ \text{Spread}_{\text{i,t}}\end{pmatrix} + a_{j,2}\begin{pmatrix}lagged\\ volume_{i,t}\end{pmatrix} + a_{j,3}\begin{vmatrix}lagged\\ return_{i,t}\end{vmatrix} + a_{j,4}d_{i,j,t}^{FirstHour} + a_{j,4}d_{i,j,t}^{MidDay} + a_{j,4}d_{i,j,t}^{LastHour} + a_{j,4}d_{i,j,t}^{Change} \quad (1)$$

where $d_{i,j}$ is a dummy variable set to 1 for firm *i* and outcome j. The dummy variable $d_{i,j,t}^{FirstHour}$ is set to 1 if the time is between 10:10 AM and 11:10 AM; $d_{i,j,t}^{MidDay}$ is set to 1 between 11:10 AM and 3:00 PM; and $d_{i,j,t}^{LastHour}$ is set to 1 between 3:00 PM and 4:00 PM. The dummy variable $d_{i,j,t}^{Change}$ is equal to 0, three months before the event, and equal to 1, three months after the event. Lagged volume and lagged absolute return are cumulated over the last five minutes preceding the event. Spread is the prevailing relative spread.

Duration Model for Limit Order Cancellation and Revisions

Hasbrouck and Saar (2009, p.160) explain that neither the pricing investigation nor the logit model directly characterise how market conditions after limit order submission affect the cancellation choice. They propose the proportional hazards duration model with time varying covariates (e.g. Allison, 1995).

Following Hasbrouck and Saar (2009), the same statistical framework is adopted. In this context, fleeting orders include both cancellations and revisions.

The duration model directly test search-, chase- and cost-of-immediacy- hypothesis before and after each market structure change. The event of interest is cancellation and revision within two seconds and execution are viewed as the competing processes. Let T denote the cancellation or revision time of an order in response to changing market conditions. The survival function is S (t) = Pr (T>t). The hazard rate is the intensity of cancellation and revision over the next instant and it is formally written as follows:

$$\lambda_{i,j}(t) = -d\log(S(t))/d(t) = s(t)^{-1}S^{'}(t) \tag{2}$$

For limit order *i* of company *j*, the hazard rate is modelled with semi-parametric form. It is written as follows:

$$\lambda_{i,j}(t) = \lambda_{0,j}(t)\,e^{X_{i,j,t}\beta_j} \tag{3}$$

The hazard for a company *j* at time *t* is the product of two factors. These are the baseline hazard function $\lambda_{0,j}(t)$ that is left unspecified, and a linear function of a set of exponential covariates $x_{i,j,t}$. The components of $x_{i,j,t}$ are known as of time *t*, but need not be known at the time the order is submitted. The coefficients are estimated in a partial-likelihood framework wherein the baseline hazard rate is left unspecified.

$$\begin{aligned}\lambda_{i,j}(t) = \lambda_{0,j}(t)\exp[\beta_1\begin{pmatrix}\#\,fleeing\\ orders_{i,j}\end{pmatrix} + \beta_2\begin{vmatrix}lagged\\ return_{i,j}\end{vmatrix} + \beta_3\begin{pmatrix}lagged\\ volume_{i,j}\end{pmatrix} + \beta_4\begin{pmatrix}Relative\\ Spread_{i,j}\end{pmatrix} + \\ \beta_5 p_{i,j}^{Relative} + \beta_6\Delta q_{i,j,t}^{Same} + \beta_7\Delta q_{i,j,t}^{Opposing}]\end{aligned} \tag{4}$$

where $\#\,fleeing\,orders_{i,j}$, $lagged\,return_{i,j}$, $lagged\,volume_{i,j}$ and $Relative\,Spread_{i,j}$ are explanatory variables. The number of fleeting orders in the ten seconds prior to order submission is used to search for evidence of dynamic trading strategies, involving multiple rapid cancellations. Volume and volatility (absolute value of return) in the prior five minutes and relative spread are used to control for market conditions. These variables are standardized (within each stock) to have zero mean and unit variance. $p_{i,j}^{Relative}$, $\Delta q_{i,j,t}^{same}$ and $\Delta q_{i,j,t}^{opposing}$ directly test the three hypotheses.

The variable definitions below present the three hypotheses. These definitions are constructed for a limit buy order. Limit sell orders is defined in an analogous fashion to limit buy order.

Search hypothesis	Chase hypothesis	Cost-of-immediacy hypothesis
$p_{i,j}^{Relative} \equiv \dfrac{limitprice_{i,j} - bidprice_{i,j,t=0}}{bidprice_{i,j,t=0}}$	$\Delta q_{i,j,t}^{same} \equiv \dfrac{bidprice_{i,j,t} - bidprice_{i,j,t+1}}{bidprice_{i,j,t+1}}$	$\Delta q_{i,j,t}^{opposing} \equiv \dfrac{askprice_{i,j,t} - askprice_{i,j,t+1}}{askprice_{i,j,t+1}}$
$t = 0$ time at submission	$t = +$ instant after	

Hasbrouck and Saar (2009) explain that the incorporation of time varying covariates mimics the strategic behaviour of a trader who monitors the market. The time-varying covariates are $\Delta q_{i,j,t}^{same}$ and $\Delta q_{i,j,t}^{opposing}$. Hasbrouck and Saar (2009, p 162) argues that "a price movement away from the limit price increase a trader's propensity to cancel, and also decreases the likelihood of execution. By incorporating post-submission conditioning information, these effects are brought into the model."

Execution and cancellation (revision) times are competing processes were one process is explicitly modelled, and the other is taken as a censoring process. The censoring process is independent of the modelled event. The model is estimated separately for each stock where limit orders are tracked through the first two seconds from submissions (or revisions). Similar to the logit model, we estimate the model for large (Q1) and small (Q4) market capitalisation stocks. Table 7 reports mean and median coefficients across stocks. Two methods are used to evaluate the strength of the results; the first reports *t*-tests for the sample's mean and median coefficients, which take into account cross-sectional variability in the estimated coefficient. The second reports the number of positive and negative coefficients, and, the number of positive and negative coefficients that are significantly different from zero using the standard errors of the stock-specific coefficients. These tests assume that the sample durations are independent over time and across firms. Therefore additional tests are required to validate these assumption. To assess the independence across firms, the cross sectional properties of (martingale) residuals are examined. To assess the independence over time, hourly mean residual are constructed and the correlations between all pairs of stocks are calculated.

RESULTS

Fill Rate of Limit Orders

Table 3 reports the percentage of limit orders that are submitted, executed, fully executed and partially executed. Panel A and B presents results 3 months before and 3 months after the removal of broker IDs and price structure change, respectively. The percentage of limit orders that are submitted marginally increases after each market structure change. More specifically, the results in Panel A show, for large market capitalisation stocks, before the removal of broker IDs, of the 53% of the limit orders that were executed, 15% were partially executed and 38% were fully executed. After the removal of broker IDs, the percentage of limit orders executed decreases by approximately 1%. This reduction is mainly due to a reduction in limit orders that are fully executed.

The results in Panel B, for large market capitalisation stocks show, before price structure change, of the 39% of the limit orders that were executed, 6% were partially executed and 33% were fully executed. After the price structure change, of the 36% of the limit orders that were executed, 4% were partially executed and 32% were fully executed.

Overall the results show, after the removal of broker IDs, the percentage of limit orders that are executed, partially executed and fully executed marginally decreases. After the price structure change, the percentage limit orders that are executed decreases by approximately 3%, of which 2% is a reduction in limit orders that are partially executed and 1% is a reduction in limit orders that are fully executed. The reduction in limit orders that are fully executed is consistent Hasbrouck and Saar (2009) that find a low fill rate for INET and explain that this finding indicate the importance to recognise new ways in which trading and order choices due to technology, active trading, fragmentation, and latent liquidity.

Although the purpose of this analysis is to examine the statistics before and after each market structure change, it is worth noting the large reduction of limit orders executed in the period before and after price structure change, when compared to the period before and after the removal of broker ID. For example, after the price structure change, the results show a decrease of 17% in limit orders that are executed. This result confirms, after the price structure change, traders have less intention to let their bids and offers remain in the limit order book until execution.

TABLE 3
LIMIT ORDER SUBMISSION FREQUENCY AND FILL RATES

This table presents summary statistics of the percentage limit orders submitted, executed, fully executed and partially executed. Results are reported in quartiles were Q1 presents large market capitalisation stocks and Q4 presents small market capitalisation stocks. Limit orders submitted, is calculated as the number of limit orders submitted divided by the sum of limit orders and market orders. Executed, is calculated as the number of limit order executed divided by the total of limit order submitted. Fully executed and partially executed are calculated as a proportion of executed orders. For example, fully executed, is calculated as the percentage of fully executed times the percentage executed orders. Panel A presents statistics 3 months before and 3 months after the removal of broker IDs. Panel B presents statistics 3 months before and 3 months after the change in price structure. These statistics are the average of variables across stocks in each quartile. Standard deviations are in parentheses.

	Pre-Event				Post-Event			
MCap Groups	Limit Orders Submitted	Executed	Partially executed	Fully executed	Frequency of Limit Orders	Executed	Partially executed	Fully executed
Panel A: Removal of broker IDs								
Q1	57.87% (4.52%)	53.25% (1.88%)	14.70% (0.04%)	38.55% (0.04%)	58.4% (5.02%)	52.56% (3.28%)	15.24% (0.07%)	37.32% (0.07%)
Q2	72.22% (3.84%)	39.80% (2.75%)	11.66% (0.06%)	28.14% (0.06%)	72.29% (4.26%)	38.57% (3.71%)	11.38% (0.09%)	27.19% (0.09%)
Q3	70.52% (4.89%)	36.00% (2.9%)	11.93% (0.07)	24.07% (0.07%)	69.63% (5.79%)	35.87% (5.00%)	11.87% (0.13%)	24.00% (0.13%)
Q4	72.78% (4.66%)	32.57% (3.57%)	12.55% (0.10%)	20.02% (0.10%)	70.92% (5.99%)	32.28% (4.75%)	12.57% (0.16%)	19.71% (0.16%)
Panel B: Price structure change								
Q1	80.09% (3.33%)	39.00% (2.395)	5.57% (0.025)	33.43% (0.02%)	80.37% (2.1%)	35.93% (1.84%)	3.83% (0.02%)	32.10% (0.02%)
Q2	80.48% (1.91%)	31.32% (1.695)	4.79% (0.02%)	26.53% (0.02%)	78.5% (2.95%)	28.34% (1.85%)	4.28% (0.02%)	24.06% (0.02%)
Q3	77.94% (2.5%)	27.00% (2.12%)	4.78% (0.03%)	22.23% (0.03%)	77.38% (4.87%)	24.49% (2.18%)	4.08% (0.04%)	20.41% (0.04%)
Q4	81.23% (2.54%)	31.30% (2.06%)	5.67% (0.02%)	25.63% (0.02%)	78.58% (4.63%)	28.04% (2.09%)	4.85% (0.04%)	23.19% (0.04%)

Survival Analysis

Table 4 presents the cross-sectional average for execution, cancellation and revision probability by 2sec, 10sec, 1min, 10min and 1 hour. The results in Panel A are as follow, a) By 2 seconds, large market capitalisation stocks, after the removal of broker IDs show that limit order revisions and cancellations slightly increases and limit order executions slightly decreases. Limit order cancellations are the least probable event, followed by limit order executions, and limit order revisions are the most probable event. In addition, the probabilities for revision, cancellation and execution, across market capitalisation stocks monotonically decreases. After the removal of Broker ID, approximately 6 % of limit orders are executed by 2 sec. b) By 1 minute, the probability of limit order revisions and cancellations, for large market capitalisation stocks, from before- to after- the removal of broker IDs, increases from 3.5% to 7.2% and

2.9% to 3.9%, respectively. After the removal of Broker IDs, approximately 11% of limit orders are executed by 1 min.

Turning to Panel B the following results are: a) By 2 seconds, large market capitalisation stocks, after price structure change show that approximately 19% of limit orders are revised, 9% are cancelled and 4% are executed. Limit order executions are the least probable event. Small market capitalisation stocks (Q4) show, approximately 9% of limit orders is revised, 8% is cancelled and 1% is executed. After the price structure change, approximately 2% of limit orders are executed by 2 sec. b) By 1 minute, the probability of limit order revisions and cancellations, for large market capitalisation stocks, from before to after the price structure change, increases from 25.3% to 32.8 % and 11.11% to 17.70%, respectively. After the price structure change, approximately 6% of limit orders are executed by 1 min. Overall the results show, for large market capitalisation stocks, in both market structure changes, show that the most probably event 2 seconds after a limit order is submitted or revised is a subsequent revision. However, this is more apparent after the price structure change. In addition, after the price structure change, limit order executions are the least probably event. For example, the probability of limit order execution is only 4% in comparison to the probability of limit order revisions of 19%. The shorter survival rates of fleeting orders after the removal of broker IDs is likely due to a combination of a) there being a greater opportunity for the algorithms to remain undetected, and b) a greater presence of informed limit orders in the orderbook to take the other side of the algorithmic trades. In a transparent order book these limit orders would have already executed, as informed traders would submit marketable orders to avoid exposure.

TABLE 4
CUMULATIVE PROBABILITY OF LIMIT ORDER REVISIONS, CANCELLATION AND EXECUTION

This table presents cumulative probabilities for limit order revisions, cancelations and executions by 2sec, 10sec, 1min, 10min and 1 hour of submission. Results are reported in quartiles. Q1 presents large market capitalisation stocks and Q4 presents small market capitalisation stocks. The probabilities are computed as $1-S(t)$, where $S(t)$ is the survival function. The survival function is estimated using the life-table. In the estimation process for cancellations and revisions, the censored event are executions (and vice versa). Panel A presents statistics for the removal of broker IDs and Panel B for price structure change.

		Pre-Event					Post-Event				
Event	Mkt Cap	2 s	10 s	1 m	10 m	1 hour	2 s	10 s	1 m	10 m	1 hour
Panel A: Removal of Broker IDs											
Revision	Q1	0.020	0.035	0.049	0.245	0.467	0.033	0.053	0.072	0.290	0.517
	Q2	0.015	0.014	0.024	0.155	0.364	0.024	0.012	0.021	0.162	0.398
	Q3	0.007	0.014	0.022	0.101	0.247	0.011	0.019	0.028	0.132	0.325
	Q4	0.002	0.009	0.015	0.080	0.204	0.003	0.009	0.017	0.102	0.259
Cancellation	Q1	0.016	0.029	0.040	0.150	0.267	0.017	0.029	0.039	0.157	0.280
	Q2	0.018	0.037	0.047	0.196	0.337	0.016	0.029	0.040	0.185	0.319
	Q3	0.011	0.022	0.031	0.197	0.335	0.013	0.023	0.032	0.164	0.287
	Q4	0.006	0.015	0.021	0.199	0.328	0.010	0.016	0.023	0.157	0.272
Execution	Q1	0.021	0.066	0.110	0.390	0.628	0.020	0.063	0.105	0.379	0.619
	Q2	0.017	0.038	0.061	0.225	0.463	0.013	0.033	0.053	0.203	0.430
	Q3	0.011	0.027	0.043	0.170	0.394	0.009	0.023	0.037	0.154	0.366
	Q4	0.009	0.020	0.031	0.131	0.324	0.006	0.016	0.026	0.117	0.302

		Pre-Event					Post-Event				
Event	Mkt Cap	2 s	10 s	1 m	10 m	1 hour	2 s	10 s	1 m	10 m	1 hour
Panel B: Price structure change											
Revision	Q1	0.112	0.253	0.327	0.611	0.7444	0.191	0.252	0.328	0.615	0.752
	Q2	0.090	0.179	0.232	0.488	0.6491	0.080	0.160	0.212	0.476	0.645
	Q3	0.073	0.137	0.179	0.420	0.592	0.076	0.137	0.180	0.437	0.6071
	Q4	0.08	0.142	0.182	0.423	0.6112	0.091	0.151	0.193	0.432	0.6138
Cancellation	Q1	0.079	0.111	0.146	0.369	0.5581	0.093	0.157	0.177	0.465	0.558
	Q2	0.076	0.111	0.137	0.323	0.5108	0.090	0.125	0.157	0.339	0.517
	Q3	0.075	0.110	0.136	0.277	0.4467	0.080	0.133	0.158	0.305	0.476
	Q4	0.068	0.092	0.110	0.269	0.4647	0.084	0.110	0.142	0.302	0.484
Execution	Q1	0.042	0.093	0.135	0.411	0.6041	0.041	0.089	0.129	0.395	0.582
	Q2	0.037	0.063	0.083	0.249	0.4543	0.034	0.058	0.077	0.235	0.436
	Q3	0.025	0.041	0.053	0.165	0.351	0.025	0.039	0.051	0.161	0.342
	Q4	0.014	0.053	0.068	0.209	0.4156	0.019	0.047	0.063	0.201	0.410

Placement of Fleeting Orders

Table 5 reports the placement of fleeting and non-fleeting limit revisions and cancellations. The placement of limit orders are determined by the location of the limit order price, relative to the same-side BBO, at the time the order was submitted or revised. Panel A presents the placements of limit orders before and after the removal of broker IDs and Panel B, before and after the price structure change. Panel A reports the following results; a) for large market capitalisation stocks, fleeting cancellation are mostly placed at-the-market. For example, after the removal of broker IDs, large market capitalisation stocks show that 54% of fleeting cancellations take place at-the-market, whereas small market capitalisation stocks show that 50% of fleeting cancellations takes place at-the-market, b) Most importantly, after the removal of broker ID, fleeting revisions that are placed behind-the-market decreases by approximately 6% and fleeting revisions that are placed ahead-of-the-market increases by approximately 11%. However, this increase, the majority of fleeting revisions is still placed behind-the-market. Non-fleeting cancellation and revisions for large market capitalisation stocks, after the removal of broker IDs are mostly placed at-the-market.

TABLE 5
PLACEMENT OF LIMIT ORDER CANCELLATION AND REVISIONS

This table presents summary statistic of the placement of fleeting and non-fleeting revisions and cancellations across quartiles. Q1 presents large market capitalisation stocks and Q4 presents small market capitalisation stocks. Panel A present statistics before and after the removal of broker IDs, and Panel B presents statistics before and after the price structure change. The first line in each quartile reports % Orders, this is the average percentage of fleeting and non-fleeting cancelations and revisions, relative to each group (i.e. fleeting and non-fleeting). The remaining three lines in each quartile reports the sub-classifications for fleeting and non-fleeting revisions and cancellation, by the location of limit order price, relative to the same-side best bid or offer prices (BBO) at the time the order was submitted. These sub-classifications are: (a) ahead BBO, (a) at BBO, and (c) behind of BBO. For example, ahead of BBO, for a buy (sell) order means that it was submitted (revised) at a price that is higher (lower) than the best bid (ask). Percentages sum vertically to 100% within each category.

		Pre-Event				Post-Event			
		% Orders Cancelled		% Orders Revised		% Orders Cancelled		% Orders Revised	
MktCap		≤ 2 sec	≥ 2 sec	≤ 2 sec	≥ 2 sec	≤ 2 sec	≥ 2 sec	≤ 2 sec	≥ 2 sec
Panel A: Removal of broker IDs									
Q1	% Orders	12.40	87.6	8.09	91.91	12.42	87.58	13.03	86.97
	Ahead	12.39	5.98	11.2	8.06	17.26	8.79	18.9	10.98
	At	55.81	46.78	41.1	35.75	53.71	50.49	39.56	45.44
	Behind	31.8	47.24	47.7	56.19	29.03	40.72	41.54	43.58
Q2	% Orders	9.54	90.46	6.48	93.52	7.61	92.39	8.40	91.60
	Ahead	7.33	3.67	9.61	6.02	11.27	5.28	11.59	8.84
	At	58.71	43.21	43.09	33.19	55.97	49.96	41.14	42.93
	Behind	33.96	53.12	47.3	60.79	32.76	44.76	47.27	48.23
Q3	% Orders	4.93	95.07	3.62	96.38	6.15	93.85	5.4	94.6
	Ahead	4.54	0.91	1.18	1.96	5.76	0.9	9.07	3.76
	At	59.71	43.21	43.15	31.45	51.71	49.45	42.77	39.2
	Behind	35.75	55.88	55.67	66.59	42.53	49.65	48.16	57.04
Q4	% Orders	2.96	97.04	1.4	98.6	3.79	96.21	4.4	95.6
	Ahead	0.61	0.79	0.40	0.98	1.93	0.65	5.07	2.16
	At	61.56	41.32	41.71	30.83	50.18	48.79	45.89	37.17
	Behind	37.83	57.89	57.89	68.19	47.89	50.56	49.04	60.67
Panel B: Price structure change									
Q1	% Orders	29.05	70.95	32.32	67.68	31.46	68.54	38.32	61.68
	Ahead	21.95	14.19	29.1	16.17	26.56	16.35	37.98	18.28
	At	48.83	44.47	33.67	40.75	50.68	46.87	26.21	47.65
	Behind	29.22	41.34	37.23	43.08	22.76	36.78	35.81	34.07
Q2	% Orders	27.94	72.06	23.86	76.14	30.41	69.59	28.65	71.35
	Ahead	16.95	9.96	21.67	12.2	19.46	13.24	29.11	13.67
	At	52.16	42.28	40.23	41.43	53.78	47.09	33.02	48.52
	Behind	30.89	47.76	38.1	46.37	26.76	39.67	37.87	37.81
Q3	% Orders	26.2	73.8	20.75	79.25	30.1	69.9	27.56	72.44
	Ahead	11.29	6.04	17.17	11.25	11.89	9.12	19.09	9.25
	At	43.45	43.67	43.5	48.31	57.55	50.67	39.87	51.95
	Behind	45.26	50.29	39.33	40.44	30.56	40.21	41.04	38.8
Q4	% Orders	24.49	75.51	19.58	80.42	26.47	73.53	25.37	74.63
	Ahead	6.17	2.24	13.18	9.28	6.37	4.08	14.08	7.31
	At	41.76	42.78	46.17	52.31	57.2	49.36	41.43	50.67
	Behind	52.07	54.98	40.65	38.41	36.43	46.56	44.49	42.02

Turning to Panel B, the results are as follows; a) for large market capitalisation stocks, fleeting cancellation are mostly placed at-the-market, which increases by approximately 2% from before- to after-the price structure change. For example, after the price structure change, large market capitalisation stocks show that 51% of fleeting cancellations take place at-the-market, whereas small market capitalisation stocks show 57%, b) interestingly, before the price structure change, 37% of fleeting revisions are placed behind-the-market.

Overall, the results show that the percentage of fleeting revisions that are place ahead-of-the-market increases, after both market structure changes. In particular, after the market structure change, fleeting revisions are mostly placed ahead-of-the market. Hasbrouck and Saar (2009, p.155) explain that "submitting a limit order at a slightly better price could be motivated by the desire to obtain price priority (i.e., jump to the head of the queue), or it could indicate a search for hidden orders whereby the searcher first tries the most favourable price".

Multinomial Logit Analysis

Table 6 reports the base case and the difference in probabilities between the base case and the shifted case. The explanatory variables, lagged volume and volatility can be interpreted as follows; if the probability of fleeting revisions and cancelations are positively related to an increase in lagged volume or volatility then, fleeting revisions and cancellations behave similarly to market orders that demands liquidity. Relative spread on the other hand, can be interpreted as follow; a wider spread means that the probability of fleeting orders (i.e. cancellations and revisions) increase because there are more price points at which to search for latent liquidity inside the spread. (e.g. Hasbrouck and Saar ,2009, p158).

Spread, lagged volume and lagged absolute return are standardized within each firm to have a zero mean and unit variance. The inclusion of the firm-dummies ensures that the average within stock residuals is effectively zero.

The results in Panel A, for limit order submission to the subsequent event (i.e. fleeting execution, cancellation or revision) are as follows:

a) The effect of an increase in lagged volume and volatility: for large market capitalisation stocks, the probability of regular limit orders decreases by 0.0473% and 0.0827%, respectively. The probability of market order decreases by 0.0444% and 0.0891%, respectively. The probability of fleeting executions, revisions, cancellations marginally increases. Small market capitalisation stocks show similar results, but the probability shifts are smaller.
b) The effect of an increase in the prevailing spread: for large market capitalisation stocks, the probability of regular limit orders and market orders increases by approximately 0.1087% and 0.0473%, respectively. The probability of fleeting executions, revisions, cancellations marginally decreases. For small market capitalisation stocks, a wider spread, leads to a lower probability in fleeting executions and cancellations and a higher probability in fleeting revisions and market orders.

The results in Panel A, for limit order revisions to the subsequent event are as follows:

a) The effect of an increase in lagged volume and volatility: for large market capitalisation stocks, the probability of regular limit order revision marginally decreases. The probability of fleeting executions, revisions and cancellations increases. From these, the probability of fleeting revisions mostly increases by 0.0029% and 0.0025%, respectively.
b) The effect of an increase in the prevailing spread: for large market capitalisation stocks, the probability of regular limit order and fleeting executions decreases by approximately 0.0056% and 0.0005%. The probability of fleeting revisions and cancellations increases by approximately 0.0005% and 0.0003%.

In summary, the results in Panel A suggest that a) limit order revisions that are subsequently revised (within 2 seconds) mostly behave like market orders that demands liquidity, and b) the effect of an increase in the prevailing spread marginally increases the probability of limit orders revisions that are subsequently revised and cancelled (within 2 seconds).

Hasbrouck and Saar (2009) explains that the increased probability of fleeting orders, in the presence of a wider spreads is in line with the search hypothesis, were a limit order seeking latent liquidity achieves either a hidden execution, a rapid execution, or is quickly cancelled. Before and after the implementation of the removal of broker IDs, undisclosed orders was not yet an active order type, hence, there was no need to search for latent liquidity. Furthermore, consistent with results in Table 4, after the removal of broker IDs, the probability of execution decreases and probability of fleeting revisions increases.

The results in Panel B, for limit order submission to the subsequent event are as follows:

a) The effect of an increase in lagged volume and volatility: large market capitalisation stocks show the probability of regular limit orders marginally decrease. The probability of fleeting executions, revisions, cancellations and market orders increases. Small market capitalisation stocks show that the probability for regular limit orders decreases whereas, market orders, fleeting execution, revisions and cancellations increases.
b) The effect of an increase in the prevailing spread: large market capitalisation stocks show that the probability of regular limit orders and market orders decreases, whilst the probability of fleeting executions, revisions, cancellations increases.

The results in Panel B, for limit order revisions to the subsequent event are as follows:

a) The effect of an increase in lagged volume and volatility: large market capitalisation stocks show similar results, whereby the effect of an increase in lagged volume and volatility decreases the probability of regular limit orders. Consistent with the previous results, the probability of fleeting revisions mostly increased by approximately 0.0047% and 0.0021%, respectively.
b) The effect of an increase in the prevailing spread: The probability of fleeting revisions and executions increase by approximately 0.0131% and 0.0132 %.

In summary, the results in Panel B suggest that a) limit order revisions that are subsequently revised mostly behave like market orders that demands liquidity, and b) the effect of an increase in the prevailing spread mostly increases the probability of limit orders revisions that are subsequently revised. This evidence supports the proposition that fleeting revisions might be used to search for latent liquidity inside the spread. Overall, these results are consistent with a meaningful partition of the limit order set, i.e., that fleeting orders are different than the patient limit orders.

TABLE 6
MULTINOMIAL LOGIT ANALYSIS

This table presents a multinomial logit analysis. The events are categorised as follows a) Limit order submission to subsequent event (i.e. regular limit order, limit orders executed within two second, revised limit order within two seconds , cancelled limit order within two seconds and market order) , b) limit order revision to subsequent event(i.e. regular limit order revision, limit orders executed within two seconds, revised limit order within two seconds , cancelled limit order within two seconds). The sample comprise of 80 stocks within S&P200 that are ranked by market capitalisation. Q1 presents large market capitalisation stocks and Q4 small market capitalisation stocks. $\pi_{ij,t}$ is the probability that event t for firm i has outcome j. $d_{i,j}$ is a dummy variable set to one for firm i and outcome j. The dummy variable $a_{j,4}d^{FirstHour}_{i,j,t}$ is set to one if the time is between 10:10 AM and 11:10 AM; $a_{j,4}d^{MidDay}_{i,j,t}$ is set to one between 11:10 AM and 3:00 PM; $a_{j,4}d^{LastHour}_{i,j,t}$ and is set to one between 3:00 PM and 4:00 PM. The dummy variable $d^{Change}_{i,j,t}$ is equal to 0, three months before each event, and is equal to 1 three months after each event. Lagged volume and lagged absolute return are cumulated over the last five minutes. Spread is the prevailing relative spread. The base case is the implied event probabilities when all the explanatory variables are set to the means. The remaining columns reports differences in probabilities, between the base case and the shifted case. Standard errors are computed using the delta method and are in parentheses. Panel A presents results 3 months before and after the removal of broker IDs, and Panel B presents results 3 months before and after the change in the price structure for exchange fees.

$$\log\left(\frac{\pi_{i,j,t}}{\pi_{i,t,0}}\right) = a_{i,j,0}d_{i,j} + a_{j,1}\begin{pmatrix}\text{Relative}\\ \text{Spread}_{i,t}\end{pmatrix} + a_{j,2}\begin{pmatrix}\textit{lagged}\\ \textit{volume}_{i,t}\end{pmatrix} + a_{j,3}\begin{vmatrix}\textit{lagged}\\ \textit{return}_{i,t}\end{vmatrix} + a_{j,4}d^{FirstHour}_{i,j,t} + a_{j,4}d^{MidDay}_{i,j,t} + a_{j,4}d^{LastHour}_{i,j,t} + a_{j,4}d^{Change}_{i,j,t}$$

	Limit order submission to subsequent event						Limit order revision to subsequent event					
MktCap Group	Outcome	Base Case	Relative Spread	Lagged Volume	Lagged Return	Change $d^{Change}_{i,j,t}$	Outcome	Base Case	Relative Spread	Lagged Volume	Lagged Return	Change $d^{Change}_{i,j,t}$
Panel A: Removal of broker IDs												
Large	Regular limit order	0.5411	-0.1087	-0.0473	-0.0827	0.0114	Regular Revision	0.9057	-0.0056	-0.0006	-0.0039	0.0156
		(0.0008)	(0.0013)	(0.0011)	(0.0011)	(0.0017)		(0.0011)	(0.0007)	(0.0009)	(0.0009)	(0.0017)
	Executed $\leq$ 2 Sec	0.0182	-0.0049	0.0015	0.0041	-0.0007	Executed $\leq$ 2 Sec	0.0273	-0.0005	0.0023	0.0019	-0.0012
		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0004)		(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.001)
	Revised $\leq$ 2 Sec	0.0021	-0.0004	0.0001	0.0003	0.0001	Revised $\leq$ 2 Sec	0.0563	0.0005	0.0029	0.0025	0.0069
		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)		(0.0009)	(0.0005)	(0.0007)	(0.0007)	(0.0012)
	Cancelled $\leq$ 2 Sec	0.0132	-0.0028	0.0013	0.0019	0.0014	Cancelled $\leq$ 2 Sec	0.0107	0.0003	0.0012	0.0005	0.0008
		(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)		(0.0004)	(0.0003)	(0.0002)	(0.0003)	(0.0006)
	Market order	0.4253	-0.1167	0.0444	0.0891	0.011						
		(0.0008)	(0.0013)	(0.0011)	(0.0011)	(0.0017)						
Small	Regular limit order	0.6875	-0.0089	-0.012	-0.0252	0.0046	Regular Revision	0.9336	-0.0034	-0.0003	-0.0017	0.005
		(0.6924)	(0.0013)	(0.0014)	(0.0014)	(0.0024)		(0.2122)	(0.0024)	(0.0005)	(0.0005)	(0.004)
	Executed $\leq$ 2 Sec	0.0106	-0.0055	0.0007	0.0021	-0.0022	Executed $\leq$ 2 Sec	0.0169	-0.0035	0.0003	0.0017	-0.0052
		(0.0119)	(0.0003)	(0.0002)	(0.0002)	(0.0005)		(0.0038)	(0.0008)	(0.0004)	(0.0005)	(0.0014)

Limit order submission to subsequent event							Limit order revision to subsequent event					
MktCap Group	Outcome	Base Case	Relative Spread	Lagged Volume	Lagged Return	Change $d_{i,j,t}^{Change}$	Outcome	Base Case	Relative Spread	Lagged Volume	Lagged Return	Change $d_{i,j,t}^{Change}$
	Revised $\leq$2 Sec	0.0018	0.0000	0.0000	0.0003	0.0000	Revised $\leq$2 Sec	0.0376	0.0000	0.0000	0.0000	0.0004
		(0.0024)	(0.0001)	(0.0001)	(0.0001)	(0.0002)		(0.1903)	(0.0002)	(0.0001)	(0.0000)	(0.0002)
	Cancelled $\leq$2 Sec	0.0167	-0.0005	0.0013	0.0017	-0.0036	Cancelled $\leq$2 Sec	0.0119	0.0001	0.0000	0.0000	0.0002
		(0.0184)	(0.0004)	(0.0002)	(0.0003)	(0.0007)		(0.1065)	(0.0021)	(0.0003)	(0.0001)	(0.0036)
	Market order	0.2768	0.0149	0.0100	0.0293	0.0011						
		(0.2816)	(0.0013)	(0.0013)	(0.0014)	(0.0024)						
Panel B: Change in the price structure												
Large	Regular limit order	0.6265	-0.0042	-0.0008	-0.0183	0.0068	Regular Revision	0.6732	-0.0003	-0.0072	-0.030	0.0089
		(0.0009)	(0.0009)	(0.001)	(0.0011)	(0.0017)		(0.001)	(0.001)	(0.0011)	(0.0011)	(0.0018)
	Executed $\leq$ 2 Sec	0.0344	0.012	0.002	0.006	-0.0024	Executed $\leq$ 2 Sec	0.0233	0.0131	0.0017	0.0064	-0.0089
		(0.0004)	(0.0005)	(0.0003)	(0.0003)	(0.0006)		(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0007)
	Revised $\leq$ 2 Sec	0.0382	0.0004	0.0019	0.0047	0.0030	Revised $\leq$ 2 Sec	0.2679	0.0132	0.0047	0.0212	0.0102
		(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0007)		(0.0009)	(0.001)	(0.001)	(0.001)	(0.0017)
	Cancelled $\leq$ 2 Sec	0.1007	0.0004	0.0062	0.0088	0.0094	Cancelled $\leq$ 2 Sec	0.0357	0.0040	0.0008	0.0023	0.0036
		(0.0006)	(0.0006)	(0.0005)	(0.0006)	(0.0011)		(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0006)
	Market order	0.2003	-0.007	0.0092	0.0012	0.0021						
		(0.0007)	(0.0007)	(0.0009)	(0.0009)	(0.0014)						
Small	Regular limit order	0.6201	-0.0319	-0.019	-0.0147	-0.0178	Regular Revision	0.7539	-0.0038	-0.002	-0.0216	0.0007
		(0.0019)	(0.0024)	(0.0022)	(0.0022)	(0.0039)		(0.0022)	(0.0022)	(0.0024)	(0.0024)	(0.0042)
	Executed $\leq$ 2 Sec	0.013	0.0037	0.0013	0.0025	-0.0006	Executed $\leq$ 2 Sec	0.0198	0.0082	0.0021	0.0042	-0.0010
		(0.0005)	(0.0005)	(0.0003)	(0.0003)	(0.0008)		(0.0008)	(0.0008)	(0.0005)	(0.0006)	(0.0012)
	Revised $\leq$ 2 Sec	0.0138	0.0009	0.0005	0.0024	0.0000	Revised $\leq$ 2 Sec	0.1934	0.0015	0.0003	0.0133	0.0084
		(0.0005)	(0.0004)	(0.0004)	(0.0004)	(0.0008)		(0.002)	(0.0009)	(0.0021)	(0.0022)	(0.0038)
	Cancelled $\leq$ 2 Sec	0.1246	0.0044	0.0075	0.0031	0.0163	Cancelled $\leq$ 2 Sec	0.033	-0.0035	0.0039	0.004	0.0028
		(0.0014)	(0.0014)	(0.0013)	(0.0015)	(0.0025)		(0.0009)	(0.0012)	(0.001)	(0.001)	(0.0017)
	Market order	0.2285	-0.0334	0.0283	0.0129	0.0022						
		(0.0016)	(0.0024)	(0.002)	(0.002)	(0.0034)						

Duration Model for Limit Order Cancellation and Revisions

The duration model examines how the market conditions affect the subsequent choice after a limit order is submitted or revised. Hasbrouck and Saar (2009, p.160) explains that the drivers behind these rapid cancellations depend on what happens to the best price immediately after the submission. In fact both the chase and cost-of-immediacy hypotheses, specifically state that fleeting orders are a by-product of dynamic strategies that involve order revision in response to changing market conditions. The proportional hazards duration model with time-varying covariates is estimated separately for each stock before and after each market structure change.

Table 7 reports the mean and median of the coefficients' estimates for large (Q1) and small (Q4) market capitalisation stocks. Each quartile comprise of twenty stocks, which is a size-stratified subsample of 80 from among 200 stocks. To evaluate the strength of the results *t*-tests are reported for the mean and median coefficients. This takes into account the cross-sectional variability of the estimated coefficients. In addition, the numbers of positive and negative coefficients as well as the number of statistically significant positive and negative coefficients are reported.

Panel A and B reports the results before and after the removal of broker IDs. These are as follows: a) for large market cap stocks, before and after the removal of broker IDs, the coefficients for lagged absolute return, volume and the prevailing spread are positive. In particular, for large market capitalisation stocks, after the removal of broker IDs, 11 out of 18, 9 out of 16 and 7 out of 15 coefficients are positive and statistically significant for lagged return, lagged volume and relative spread, respectively, b) large and small market capitalisation stocks, before and after the removal of broker IDs show that multiple fleeting orders arise may be used as part of a dynamic strategy or that fleeting orders arise as a result of previous fleeting orders.

Turning to the three hypotheses the results are as follows:

> *$H_{1.1}$: (Chase hypothesis). If the chasing effect is visible, the mean coefficient $\Delta q_{i,j,t}^{Same}$ is expected to be positive. This implies that the probability of a fleeting buy (sell) revision should increase if the same-side BBO goes up (down) because traders revise their limit orders at more aggressive prices to seek immediate execution.*

Before the removal of broker IDs, the results show no evidence that supports the chase hypothesis, for both large and small market capitalisation stocks. However, after the removal of broker IDs, large market capitalisation stocks show evidence in favour of the chase hypothesis where 11 out of 13 coefficients are positive and statistically significant.

> *$H_{1.2}$: (Cost-of-immediacy hypothesis). If fleeting orders are used to switch from a limit order to a market order, the mean coefficient $\Delta q_{i,j,t}^{Opposing}$ is expected to be negative. For example, a negative mean coefficient implies that for a buy order, if the ask moves down after submission or revision, fleeting cancellation intensity increases.*

Before and after the removal of broker IDs, the results show no evidence supporting the cost-of-immediacy hypothesis, for both large and small market capitalisation stocks.

> *$H_{1.3}$: (Search hypothesis). If fleeting orders are used to search for latent liquidity, the mean coefficient $p_{i,j}^{Relative}$ is expected to be positively related to a higher (lower) limit order price for a buy (sell) order. This implies that the probability of fleeting revisions should be higher, for more aggressive orders.*

TABLE 7
COX PROPORTIONAL HAZARD MODEL

This table presents fleeting order cancellation and revision probabilities. The cancellation and revision hazard rate for limit order *i* of firm *j* at time *t* (relative to the time of order submission or revision) is modelled as the proportional hazard duration model. Results are reported for large market capitalisation (Q1) stocks and small market capitalisation stocks (Q4). $\lambda_{0,j}(t)$ is the unspecified baseline hazard rate. Lagged absolute value of return and volume are cumulated over the preceding five minutes and relative spread is computed at the time of order submission. The #fleeting orders is the number of fleeting orders in the preceding ten seconds. $\beta_5 p_{i,j}{}^{Relative}$, $\Delta q_{i,j,t}^{Same}$ and $\Delta q_{i,j,t}^{Opposing}$ are three hypothesis. $\Delta q_{i,j,t}^{Same}$ and $\Delta q_{i,j,t}^{Opposing}$ are time-varying covariates. Limit orders are tracked through the first two seconds of submission or revision. Panel A and B presents statistics 3 month before and after the removal of broker IDs, and Panel C and D presents statistics 3 month before and after the change in the price structure for exchange fees.

$$\lambda_{i,j}(t) = \lambda_{0,j}(t)\exp[\beta_1\begin{pmatrix}\#\,fleeing\\ orders_{i,j}\end{pmatrix} + \beta_2\begin{vmatrix}lagged\\ return_{i,j}\end{vmatrix} + \beta_3\begin{pmatrix}lagged\\ volume_{i,j}\end{pmatrix} + \beta_4\begin{pmatrix}Relative\\ Spread_{i,j}\end{pmatrix} + \beta_5 p_{i,j}{}^{Relative} + \beta_6\Delta q_{i,j,t}^{Same} + \beta_7\Delta q_{i,j,t}^{Opposing}]$$

Market Cap		# Fleeting Orders	Lagged Return	Lagged Volume	Relative Spread	$\beta_5 p_{i,j}{}^{Relative}$	$\Delta q_{i,j,t}^{Same}$	$\Delta q_{i,j,t}^{Opposing}$
Panel A: Pre-Removal of broker IDs								
Large	Mean	0.129	0.145	0.129	0.888	-8.576	-2.851	2.847
	Median	0.122	0.141	0.049	0.016	-5.517	-1.368	1.384
	t-test (p-value)	<.0001	<.0001	0.050	0.039	0.017	0.031	0.021
	# coef with t-stat < -1.96	0	3	2	0	3	5	2
	# coef with t-stat > +1.96	15	8	7	4	1	0	9
	# coef with > 0	19	13	15	15	5	4	11
	# coef with < 0	1	7	5	5	15	16	9
Small	Mean	-1.009	0.170	0.165	1.091	-3.733	-3.810	-0.755
	Median	0.167	0.104	0.023	0.008	-3.750	0.364	0.100
	t-test (p-value)	0.040	0.074	0.429	0.318	0.724	0.129	0.612
	# coef with t-stat < -1.96	3	0	3	1	2	3	5
	# coef with t-stat > +1.96	0	9	5	3	0	3	6
	# coef with > 0	4	14	11	11	8	9	9
	# coef with < 0	16	6	9	9	12	11	11

Market Cap		# Fleeting Orders	Lagged Return	Lagged Volume	Relative Spread	$\beta_5 p_{i,j}^{Relative}$	$\Delta q_{i,j,t}^{Same}$	$\Delta q_{i,j,t}^{Opposing}$
Panel B: Post-Removal of broker IDs								
Large	Mean	0.138	0.109	0.057	0.032	-1.523	1.758	1.112
	Median	0.121	0.110	0.072	0.024	-2.358	1.594	1.594
	t-test (p-value)	<.0001	<.0001	0.022	0.045	0.008	0.003	0.0018
	# coef with t-stat < -1.96	0	0	0	0	2	2	3
	# coef with t-stat > +1.96	14	11	9	7	4	11	7
	# coef with > 0	19	18	16	15	9	13	13
	# coef with < 0	1	2	4	5	11	7	7
Small	Mean	0.213	0.176	0.165	0.142	-2.567	0.138	-2.249
	Median	0.184	0.077	0.093	0.160	-3.254	0.676	-0.539
	t-test (p-value)	0.0003	0.016	0.010	0.122	0.035	0.025	0.013
	# coef with t-stat < -1.96	0	0	0	0	0	0	4
	# coef with t-stat > +1.96	8	8	11	5	5	5	2
	# coef with > 0	16	16	18	17	12	11	6
	# coef with < 0	4	4	2	3	8	9	14
Panel C: Pre-Price structure change								
Large	Mean	0.1634	0.0199	0.0143	0.0124	-0.0858	1.2548	-0.1248
	Median	0.2195	0.2195	0.0066	0.0073	-0.0066	2.1230	-0.2219
	t-test (p-value)	<.0001	0.0115	0.0147	0.0010	0.0537	0.002	0.0340
	# coef with t-stat < -1.96	1	5	6	4	4	1	8
	# coef with t-stat > +1.96	11	9	9	9	6	7	3
	# coef with > 0	15	16	13	13	9	15	7
	# coef with < 0	5	4	7	7	11	5	13
Small	Mean	0.0327	0.0720	0.0668	0.0258	0.0179	0.5572	-0.1505
	Median	0.0162	0.0162	0.0665	0.0254	0.0102	0.1696	-0.0291
	t-test (p-value)	0.0069	0.0515	<.0001	0.0038	0.0049	0.060	0.0285
	# coef with t-stat < -1.96	5	4	0	3	1	2	14
	# coef with t-stat > +1.96	7	5	7	9	6	7	0
	# coef with > 0	12	12	18	15	15	12	10
	# coef with < 0	8	8	2	5	5	9	10

Market Cap		# Fleeting Orders	Lagged Return	Lagged Volume	Relative Spread	$\beta_5 p_{i,j}{}^{Relativ}$	$\Delta q_{i,j,t}^{Same}$	$\Delta q_{i,j,t}^{Opposing}$
Panel D: Post-Price structure change								
Large	Mean	0.1247	0.0133	0.0027	0.0182	0.0657	1.3973	-0.1453
	Median	0.1796	0.1796	0.0025	0.0173	0.0034	0.8833	-0.0934
	t-test (p-value)	0.0002	0.0686	<.0001	0.0037	0.0029	0.004	0.0289
	# coef with t-stat < -1.96	1	0	0	4	3	0	11
	# coef with t-stat > +1.96	13	12	14	9	7	11	1
	# coef with > 0	17	16	19	13	12	18	5
	# coef with < 0	3	4	1	7	8	2	15
Small	Mean	0.0654	0.0211	0.0147	-0.0235	0.0111	0.8524	-0.1863
	Median	0.0832	0.0832	0.0339	-0.0247	0.0031	0.8649	-0.0752
	t-test (p-value)	0.0461	0.0745	0.0381	0.0060	0.090	0.0005	0.0385
	# coef with t-stat < -1.96	3	2	3	6	0	3	9
	# coef with t-stat > +1.96	9	8	6	4	7	7	3
	# coef with > 0	15	15	12	4	17	11	8
	# coef with < 0	5	5	8	16	3	9	12

Before and after the removal of broker IDs, the results show no evidence that supports the search hypothesis, for both large and small market capitalisation stocks. For example, before the removal of broker IDs, the mean coefficient $p_{i,j}^{Relative}$ is -8.576, where 3 out of 15 coefficients are negative and statistically significant. After the removal of broker IDs, the mean coefficient is -1.523, where 2 out of 11 coefficients are negative and statistically significant.

The results in Panel A and B show that after the removal of broker IDs traders pursue a dynamic strategy in which they revise limit orders as the market moves away from the original limit order.

Panel C and D reports the results before and after the price structure change. The results are as follows; a) Large market capitalisation stocks, before and after the price structure change show a positive mean coefficient for lagged return, lagged volume and relative spread. For example, after the price structure change, 12 out of 16, 14 out of 19 and 9 out of 13 coefficients are positive and statistically significant for lagged return, lagged volume and relative spread, respectively, b) large and small market capitalisation stocks, before and after the price structure change show that multiple fleeting orders arise may be used as part of a dynamic strategy or that fleeting orders arise as a result of previous fleeting orders. For example, before the price structure change the mean coefficient for #Fleeting orders is 0.1634, were 11 out of 15 are positive and significant. After the price structure change the mean coefficient for #Fleeting orders is 0.1247, were 13 out of 17 are positive and significant.

Turning to the three hypotheses the results are as follows:

$H_{1.1}$: (Chase hypothesis)

The results show supporting evidence for this hypothesis, before and after the price structure change. For example before the price structure change the mean coefficient is 1.2548, were 7 out of 15 coefficients are positive and statistically significant. After the price structure change the mean coefficient is 1.3973 were 11 out of 18 coefficients are positive and statistically significant.

$H_{1.2}$: (Cost-of-immediacy hypothesis)

The results show supporting evidence for this hypothesis, before and after the price structure change. For example before the price structure change the mean coefficient is -0.1248, were 8 out of 13 coefficients are negative and statistically significant. After the price structure change the mean coefficient is -0.1453 were 11 out of 15 coefficients are negative and statistically significant.

$H_{1.3}$: (Search hypothesis)

The results show supporting evidence for this hypothesis, after the price structure change. For example, after the price structure change the mean coefficient is 0.0657 were 7 out of 12 coefficients are positive and statistically significant.

The results in Panel C and D show, that after the price structure change, fleeting orders are used to search for latent liquidity and traders more often switch from a limit order to a market order. Supporting evidence of the search hypothesis is particular interesting, because this confirms that fleeting orders are used to search for latent liquidity with the introduction of undisclosed orders.

Hasbrouck and Saar (2009) , offers another explanation, as oppose to the proposition that, fleeting order increase as traders cancels limit orders because it become cheaper to demand than to supply liquidity. For example, the trader could interprets a drop in the ask as a signal of new negative private information, therefore cancellations is a response to a perceived increase in information asymmetry.

Hasbrouck and Saar (2009) pointed out that the tests that are used to evaluate the strength of the results assumes that the sample durations are independent over time and across firms. Following, Hasbrouck (2008) the validity of this assumption is examined using the estimated (martingale) residuals for large and small market capitalisation pre and post each market structure change. To assess the independence across firms, the average within-stock first-order correlation is calculated. To assess the independence across time, hourly mean residual are constructed and the correlations between all pairs of stocks are computed.

After the removal of broker IDs the average within-stock first-order correlation for large and small market capitalisations is approximately 0.011 and 0.019, respectively. After the price structure change the average within-stock first-order autocorrelation for large and small market capitalisations is approximately 0.009 and 0.0016, respectively. The average correlation before the removal of broker IDs for large and small market capitalisation stocks is 0.008 and 0.012, respectively. After the price structure change the average correlation for large and small market capitalisation stocks is 0.005 and 0.009, respectively. These results confirm that the sample durations are independent over time and across firms.

CONCLUSION

This paper presents empirical evidence on fleeting order activity and their role in the trading process around two market structure changes in ASX. These are the removal of broker IDs and a price structure change for exchange fees. The major findings are summarised as follows:

a) The percentage of limit orders that are fully executed decreases after both market structure changes. This results is consistent with Hasbrouck and Saar (2009) that find a low fill rate for INET and explain that this indicates the importance to recognise new ways in which trading and order choices have changed due to technology, active trading, fragmentation, and latent liquidity.
b) Large market capitalisation stocks, in both market structure changes show that the most probably event 2 seconds after a limit order is submitted or revised is a subsequent revision. This confirms that traders who arrive at the market uncertain of its state quickly learn its true state by placing a limit order and watching the evolution of the market. If the uncertainty is quickly resolved, limit orders are quickly cancelled or revised. Furthermore, after the price structure change, limit order executions are the least probably event.
c) Large market capitalisation stocks, after both market structure changes show that fleeting cancellations are mostly placed at-the-market. After the removal of broker IDs, fleeting revisions are mostly placed behind-the-market. However, the percentage of fleeting revisions that are placed ahead-of-the-market increases by a significant amount. This confirms that after the removal of broker IDs, fleeting revisions are more aggressively than before the removal of broker IDs. Before the price structure change fleeting revisions are mostly placed behind-the-market and after the price structure change are mostly placed ahead-of-the-market.
d) The multinomial model suggests that the behaviour of fleeting orders (i.e. revisions and cancellations) is different from regular limit order submissions or revisions. In particular, large market capitalisation stocks, for both market structure changes, show that limit order revisions that are subsequently revised behave similar to market orders that demands liquidity. In particular, the evidence before and after the price structure change suggests that fleeting revisions might be used to search for latent liquidity inside the spread.
e) The hypothesis tested concludes three main results. The first, after the removal of broker IDs traders pursue a dynamic strategy in which they revise limit orders as the market moves away from the original limit order. The second, after the price structure change, fleeting orders are used to search for latent liquidity within the spread. The third, after the price structure change, traders more often switch from a limit order to a market order as it becomes cheaper to demand than to supply liquidity.

Overall, the evidence in this paper suggests that traders do pursue dynamic order placement strategies, whereby they actively monitor limit orders. This is also consistent with Liu (2009), that suggest, alleviating the risk of being picked-off or the risk of non-execution, traders can monitor the market and cancel or revise orders accordingly. Therefore, a theoretical order choice model that incorporates the limit order decision to cancel or revise will improve the understanding of order dynamics in a high frequency trading environment.

ENDNOTES

1. http://www.asxgroup.com.au/media/PDFs/20100603_asx_fees_and_rebates.pdf
2. http://www.asx.com.au/trading_services/new_market_services.htm
3. http://www.asx.com.au/documents/resources/asx_trade_new_order_types.pdf
4. http://www.asx.com.au/documents/resources/asx_trade_new_order_types.pdf
5. http://www.asx.com.au/trading_services/new_market_services.htm
6. For more information on the calculation method used see, www.standford.edu/~tomz/software/clarify.pdf

REFERENCES

Allison, P.D., 1995. Survival Analysis Using the SAS System: a Practical Guide. *SAS Institute, Cary,* NC.

Boehmer, E., Saar, G., Yu, L., 2005. Lifting the veil: An analysis of pre-trade transparency at the NYSE. *Journal of Finance* 60, 783–815.

Cao, C., Hansch, O., Wang, X., 2008. Order placement strategy in a pure limit order book market. *The Journal of Financial Research* 31, 113–140.

Comerton-Forde, C., Frino,A., and Mollica, V., 2005, The impact of limit order anonymity on liquidity: Evidence from Paris, Tokyo, and Korea, *Journal of Economics and Business* 57, 528-540.

Fong, L., Liu, W.-M., 2010. Limit order revisions. *Journal of Banking and Finance* 34, 1873–1885.

Foucault, T., Moinas,S., and Theissen,E., 2007, Does anonymity matter in electronic limit order markets? *Review of Financial Studies* 20, 1707-1747.

Hasbrouck, J., Saar, G., 2009. Technology and liquidity provision: The blurring of traditional definitions. *Journal of Financial Markets* 12, 143–172.

Large, J., 2004. Cancellation and uncertainty aversion on limit order books. Working paper. *Nuffield College, Oxford University*.

Liu, W.-M., 2009. Monitoring and limit order submission risks. *Journal of Financial Markets* 12, 107–141.

O'Hara, M., 1995. Market Microstructure Theory, *Blackwell, Cambridge, MA*.

Yeo, W., 2005. Cancellation of limit orders. Unpublished working paper.